<Desc/Clms Page number 1>

Incorporated compressor refrigerating machine with a refrigerator with insulation by plastic foam. The desire: to limit at least unavoidable the development .du noise in the apparatuses of household, exists in particular in the refrigerators and the freezers which are equipped with compressor refrigerating machines. Essen- the tielle source of noise of these machines consisted until the most recent time of the compressor itself. However, meanwhile, one carried out .des compressing which only vibrates relatively little, in particular in the zone of frequencies ranging between 100 Hz and 10 Khz, in which the human ear is particularly responsive. The refrigerating machines which comprise compressors, of this .genre cause only seldom unpredictable noises, when for their incorporation in the case of a refrigerator, one operates with a conventional insulation, i.e. an insulation with inorganic wool, and that one respects the most single principles on the damping of the noises. The compressor is in generated attached with the case by means of rubber plugs, and guard is taken that tubular pipings, like: other .parties of the machine, does not run up the ones against other and do not run up against the case in order to cause .des rattling.

Under these conditions, still vibrations are transmitted to tell the truth - of the refrigerating machine to the case, but they are limited in amplitude by the mass of the portions of the case which are coupled directly with the vibrating portions of the refrigerating machine, and they are so highly absorbed by the insulating material, which the sound level of the radiated noises remains sufficiently low.

It created for itself a situation fully new after introduction, for the insulation of the refrigerators, the rigid plastic foams (foams of poiystyroi and polyurethane). These pre materials feel, with; thermal point of view and with, point of view of technical of manufacture, .des substantial advantages compared to traditional insulation by means of inorganic wool. In particular, when one uses the special possibilities from the point of view of technical of manufacture of these materials, and when one joins together in a unit indémon- table the inner container, it - outer case and the insulation of the refrigerator, not only .caisse it refrigerator becomes slighter, but still, it damps out notably less the vibrations that a case of conventional construction. The mechanic-acoustic factor of transmission of the case is .donc larger than up to now, i.e. the vibrations of the refrigerating machine change, in a measuring much higher, in unwanted noises. If one wanted to be satisfied to decrease the noises, only while reducing, by means of intermediate members shock absorbers, the coupling between the refrigerating machine which vibrates and the case of the refrigerator, Il would be necessary, .pour that, a substantial expenditure.

The present invention is based on the observation which it is more proper to fight the vibrations, of the refrigerating machine itself. Since one - has successful to avoid largely, by employing an insulation by plastic foam, the noises .engendrés by the compressor, as well as the rattlings of other elements who touch refrigerating machine and - case, it is, for the use of the invention, the group of the noises of flow who passes to the first planar one. In the case of l@écouiément the liquid ones and gases in lower part speed of sound, the noises are in generated caused primarily by the turbulent movements of the mixtures. The .gaz or the liquid ones which run out at moderate speed in .des closed tubes, do not generate ordinal.

<Desc/Clms Page number 2>

do not disavow considerable noises, because the low turbulent variations .de pressure do not cause considerable vibrations of the walls - tubes.

By studying more closely the phenomena of flow in the small refrigerating machines, there is exposed a mechanism - development of the noises, which is - conditioned by the constructional features .de .ces machines when one incorporates them in insulated refrigerators by plastic foam; account up to now of this mechanism had not been taken, and Il can be made ineffective by relatively single means, in accordance with the present invention.

top

What is essential for the production of vibrations in the small refrigerating machines, it is the discontinuous flow of a mixture .de vapor and liquid. Because of the difference in density which exists between the vapor and the liquid one, the various accelerations of fluid which runs out - accelerations which intervene longitudinally and transversely compared to the main direction of flow - have as a consequence of the variations puisatoires mass efforts which are exerted on the tube, and which appear by a vibration of the tubular system. The amplitude of acceleration of these vibrations is .proportionnelle with the acceleration of the drops of liquid and the report/ratio of mass of each drop of liquid compared to the mass of the accelerated portion of the tube by - this drop, including the bodies which are coupled with the tube. The amplitude speed and, consequently, the sound pressure, are directly proportional with the amplitude of the acceleration, and conversely proportional with the frequency, with various restrictions, which relate to front all the report/ratio length of the successive columns of vapor and liquid. For the frequencies - abstraction made of: certain given geometric which can have a substantial importance practical - it is the succession in the time of the drops of liquid which is determining. It depends substantially on the mass which runs out through the tube .dans the unit of times, as well as average size, .des drops, this size itself being.déterminée front all by the

superficial tension and the other conditions which influence the formation of the bubbles and .des drops. The accelerations to which the various portions of liquid are subjected are proportional at square the speeds, as with the variations relative of transverse sections which intervene along the tube, like with the curves (with being known with reverse of the values of the rays .de curve). Since generated the vapor of it has a density substantially lower than the liquid one, the volume of the mixture and, consequently - for a mass throughput and a transverse section of the tube .donnés - mean velocity of flow .dépend front all .de la content of vapor and static .pression.

Of what was said previously, Il results what follows At the time of the passage of a widening of transverse section, a drop initially accelerates the tube in the direction of flow, and, at the time of the passage of a consecutive contracting of transverse section, this acceleration takes place in reverse direction. The mass effect of the drop, in this direction, effective only when .courant it is fully.dé. do not stick, i.e. - when the drop traverses like an obturator the variations of transverse section. If, on the other hand, the drop is detached from the wall of the tube and if it preserves its kinetic energy when it traverses the widened portion of the tube, it can, when it meets the wall of the tube, in particular in the area of narrows. lies, being delayed and to give only here to the pipe an impulse in the direction of the flow. In .chacun of the cases, it occurs, during the variations of transverse sections, of the vibrations at the frequencies and amplitudes which were indicated Ci. .dessus. The drop, when it traverses a .courbure of the tube, accelerates this curve .dans a centrifugal direction compared to its - direction of past. lies.

Sections of tubes into rolled in spiral and helical obeying under special conditions. Il inter, comes here from the accelerations (and, consequently, of the vibrations), not only with the frequency of the succession of the drops, but front all, of accélé. rations with the rotational frequency of each drop, - frequency which is directly proportional with the rate of flow and conversely pro. portionnelle with the unrolled length of a whorl. Since, for the vibrations, they are not the accelerations .du fluid itself which s@écoule, but the changes .d' acceleration which are decisive, .des small .com vapor bubbles taken between long liquid columns have an effect similar to that of the small drops of liquid between lengthened vapor bubbles.

What is essential for the present invention, it is that, in the case of an incorporated compressor refrigerating machine with an insulated refrigerator by plastic foam, with a closed circuit of the refrigerating agent, in which Il exists portions of conduits which are traversed in succession alternating by vapor bubbles and .des drops of liquid, the noises which come from the pulsing forces, and in particular of the .déséquilibrées forces, coming of the rapid succession .de la vapor and liquid in the portions of conduits, in co-operation with portions of the case, is avoided, or at least reduced, by a dimensioning and/or a suitable provision of the portions of crossed conduits by the current. The dimensioning, which corres-

< Desc/Clms Page number 3>

lays with the obtaining of a reduction of the noises, can be given, for example, thanks to measuring which avoids, or which at least limits, an evaporation of the pendent refrigerating agent throttling. For this purpose, one can consider, by .exemple, a cooling of the capillary tube used like throttle member between the evaporator and the conden- sor. Since, to fully avoid the vapor formation in the capillary tube, one would need too considerable lengths .de tubes, it is indicated, .dans the .dernière, portion of capillary, to allow a reduced vapor formation. Moreover, the transverse sections, of control which decrease the speed and/or the large diameters of rolling up of capillary can be used in closed circuit. In so far as, in the according forms of execution to the present invention, one considers: portions - conduits which go rolled up helical, in particular .dans the area of the capillary tube, one can choose, a provision, substantially new and substantial for the invention, .des portions - conduits traversed by the current, in such way that one avoids .des excitations of the case of the refrigerator by uncoupling the masses which are formed by the portions of the refrigerating machine, or by coupling these masses .ou additional masses.

In the majority of constructions of refrigerating machines .à compressing, the forces pulsing and, in particular, the forces of imbalance, intervene with the sites where there are relatively considerable speeds - mixture of liquid and vapor in narrow transverse sections of tube, and in particular in the capillary one of throttling .du circuit. In many case, it is common to adapt this capillary to the condenser or the cartridge of desiccation which is connected there and - to lead this capillary to the evaporator in such way that there is an exchange - of heat with the control of suction. Being: given that capillary present length substantially larger than the control of suction, the excess length is laid out in the form of rollings up of the capillary tube. The exchange of .chalor of the capillary tube .avec the control of suction is frequently carried out in such a way that the capillary tube is introduced into the tube of suction and is welded at the place where the introduction is done. In the majority of manufacture it is known, in order to .décharger m6ca- niquernent this site of introduction, .d' to roll up the capillary one in several turns around the tube of suction. These rollings up of the capillary one, which are carried out with a relatively narrow diameter, constitute, as showed it very pushed tests, a substantial source of noises. Following a development of the present invention, one can eliminate this source from noises by modifying the provision of capillary in the area of the EM placement of inlet of the tube of suction. One can obtain this result, for example, by the fact that the capillary one which goes from the condenser to the tube of aspired. tion, préaente of rollings up only in the area in which, because of rise .de la prezsion, it is not formed vapor yet. This can mean that one gives up in theory adapting to the tube of suction, in order to discharge the site from introduction, rollings up, .par ailleurs conventional, of the capillary tube on the tube .d' suction. The provision can be such as capillary present rollings up only front and/or after the heat transfer with the tube of suction. In so far as one uses front or, after the exchanger of heat, rollings up - the capillary one, one can eliminate the source from noises which would be thus produced into giving with the curves .de capillary which are upstream exchanger of heat, a ray which is upper to 20 mm, tandi3 that the curves of the capillary one which are downstream from the exchanger .de, heat, have a ray which is upper with 40 Misters. In particular, one can choose a provision such as the curves which are front the exchanger of heat, for example rollings up, have an upper diameter with that of the tube of suction. In accordance with a development of the present invention, one can preferably obtain a .décharge site of introduction of capillary, by the fact that the tube - capillary applique .au tube of suction by a substantially straight portion, immediately front his introduction into 3rd tube of suction, and is attached mechanically in this place by a collar, a welding, a coating, by a plastic or plastic or similar. One can amusement outwardly fix at the tube .d' suction the end of the capillary one which is substantially straight, and that using a .tube of tightening. Thanks to the straight introduction of the capillary tube, one avoids the pulsing

forces in the area of the tube of suction, and in particular the forces .de imbalance, which come - from the rapid succession of the vapor and the liquid one; from this way, one eliminates a substantial source of noises.

Il is amusement possible to apply the present invention in .dispositifs which function with rollings up of capillary with the site of introduction on the tube .d' suction. In this case, conformément â the present invention, one can, in the vicinity immediate of the unavoidable curves of these portions of control, for example .de l' rolling up of the capillary tube, to fix .d' a rigid manner, mechanically, an additional mass such as the impulses .exercées on the tubular system by the drops of liquid which run out quickly through the capillary one, can cause only very low vibrations in the audible zone of frequency. The tests showed that one can obte#

<Desc/Clms Page number 4>

to nir the result wished with a relatively low additional mass. One can also give up partially or fully a special additional mass, when one rigidly joins together the tube of suction with the condenser or the cartridge of desiccation, of the refrigerating machine, so that the portions of machine are used as additional masses in order to modify the frequency of the natural oscillations .du system, and, consequently, in order to deaden the noise. The vibrations and the noises generated by the flow of the mixtures .de vapor and liquid, can be reduced by one or .plusieurs of the following measuring 1 the rate of flow in the conduits through lequelles run out constantly or temporarily, of the mixtures of vapor and of liquid, must be limited sufficiently so that, same in the changes from direction, Il does not occur longitudinal accelerations or transverse the liquid one, of more than 1000 m/s (i.e., approximately, the centuple of the acceleration of gravity). If one takes account of the possibilities of placement of the tubes .dans the aforementioned refrigerating machines, .cela means that one must avoid upper rates of flow to 5 m/s. One cannot meet this condition in the tube of throttling. In the evaporator amusement, Il can result from it from the difficul- t-pieces.

2 In the zone higher speeds, the changes of direction and the transverse variations of section must be avoided. Unavoidable changes of directions must be carried out with a radius of curvature as large as possible. For .des speeds of 10 m/s, the radius of curvature must be at least 20 mm; .pour higher speeds it must be suitably increased.

3 If one cannot observe conditions 1 and 2, one can limit the vibrations by adapting considerable masses to the places of the tubular conduits where one must expect strong amplitudes of acceleration in 3a zone of the audible frequencies.

Other essential characteristics .de la present invention will be exposed .dans the selected following shapes of execution to title .d' example. Figures 1 to 3 show initially in diagram and a rear sight like in a cut, the construction of principle of the compressor refrigerating machine and refrigerator which is associated there. The vapor of the refrigerating agent which is .conduite starting from compressor 8, by the pressure line 9 in - condenser 10 is superheated, i.e. free of liquid refrigerating agent; this vapor involves however usually a small cloud of oil. The rate of flow is low, so that same some larger drops .d' oil do not cause substantial noises. In the condenser, the rate of flow decreases further: Here amusement the flow of the mixture of vapor and liquid does not lead to .des substantial vibrations - tubular system. The liquified refrigerating agent reached, after to have traversed the cartridge of desiccation -17, the tube - capillary 11, with the state under cooled, i.e. free of vapor.

The .capillaire usually consists of a rolled up portion 12 and .une wide portion 13. High speeds which are required to obtain the fall - of wished pressure, occur .dans the capillary tube front .tout by the fact that a low portion of the refrigerating agent evaporates. With its inlet in the capillary tube liquid A usually a speed of a few metres/second. In consequence of the formation of vapor and lowering of pressure, speed increases. long the .du tube. At the end of capillary, of 14, it approach the speed of sound in the vapor of the refrigerating agent. Consequently, the curves and rollings up which exist only in the first section of the capillary one, where are yet no vapor bubble, do not cause substantial vibrations. In evaporator 15, the rates of flow are substantially lower than in the capillary one. The changes of direction and the variations of transverse section can however also lead here to vibrations. Il is added to that the local abrupt variations of pressure and speed, which are caused by the spontaneous formation of bubbles. By the control of suction .16, between the collecting container 18 and the compressor 8, i3 runs out normally only of the vapor dry, and same superheated, which .contient amusement a little oil which is involved partly in the shape of drops, and which runs out partly out of film on the wall of the tube. The speed of vapor in the control of suction usually lies between 5 and 20 m/s. It is only in the case of an unfavorable provision .des tubes that the involved oil drops cause in - control of suction of the annoying noises.

"Research - experimental, which could be amusement confirmed quantitatively by the cal bottom, showed that, in the traditional construction industry the .petites refrigerating machines, they are front all the phenomena which were described above in the capillary tube 12 and 13 and in the portion of the evaporator which is connected directly to this capillary tube of 14, like in a tube of connection not represented on figure 1, between the capillary tube 13 and the evaporator 15, which are responsible production of disturbing noises. The vibrations of the capillary tube are not only transmitted, via evaporator 15 with the case of the refrigerator, which is insulated by plastic foam - this case having: a large surface which supports the radiation of the noise -,

<Desc/Clms Page number 5>

but also via the control of suction 16, which is connected at least to a portion of the capillary tube, and that at least in a place.c'est-with-statement where this control, which passes into 23 through the .plastic wall of foam, is coupled with a more or less good damping, with the case of the refrigerator. Present case 19, - in its wall .postérieure, a window for the introduction of evaporator 15. This window is closed by an insulating plate of plastic foam 20. Compressor 8 is joined together with the case by i' intermé- diaire of rubber 21 plugs. The conden- sor 10 is carried by .cornières of fixing 22. The orifice through which the control of suction leaves inner the refrigerator between the rear wall case 19 and the insulating plate 20, is closed by a molded rubber part or a plastic mass .d' sealing. This site of passage of capillary through the rear wall of plastic foam, is shifted asymé- triquement starting from the medium, more, close on a side of the refrigerator, i.e. in an area of insulation where a more considerable rigidity is

supplied by the walls, of the refrigerator which are vertically joined the ones against the other ones. Of this manner, transmission of the oscillations - conduits of the refrigerating agent diminishes on the plastic foam.

Between items 24 and 25, the capillary tube 13 is joined together with the control of suction 16, in order to form an exchanger of heat. This portion of capillary is laid out inside control of suction, or so it is welded outwardly with this control. In order to mechanically discharge the connections from welding in the area of items 24, and 25, it is conventional to up to now roll up the capillary one around the control of suction - of a manner similar to .ce qui is represented on figures 4. and 6. On figure 4, portion 26 of the capillary tube which is downstream from serpentine 12 in the direction of flow is rolled up several times around control .d' suction. The portion 13 which is connected to it, of the capillary tube, is laid up to point 25 (. 2) along the control of suction 16 and, as it is indicated on figure 5, it is welded .par soft welding with this control. Figure 5 watch cut 27/28 through the control of suction.

Figure 6 watch another form of execution of the connection between control .d' suction and the wide portion of the capillary tube. Here the wide portion 29 of the capillary tube is inside - control of suction. The control of suction itself consists of two portions 30 and 31. The end of portion 31 is, following figures 6 and 7, deformed in order to be connected to portion 30: control of suction and with the capillary one. The connection of the three tubes is obtained by solder. Like in the form of execution of figure 4, the capillary tube is still rolled up here into 34 around the tube of suction 30, in order to .décharger mechanically the site of the welding.

Through serpentines 26, 34, the refrigerating agent runs out with the state of mixture of vapor and liquid. The proportion of vapor is volumetric lies enough large so that it, produces rates of flow enough large so that it, produces rates of flow of about size from 5 to 20 m/s. Since serpentines 26, 34 are rolled up of relatively clamped manner, Il occurs high accelerations so that same drops of liquid relatively low are enough to cause the vibration and the radiation of the noise of capillary and the control of suction which is connected to him, .ainsi que case .du refrigerating. In - reason of the geometric reports/ratios, sizes of .gouttes and bubbles. - of vapor, as well as rate of flow, it occurs, .dans the installations of this kind, a noise on a wide frequency band, this noise, because of its raised intensity, being usually felt like unpleasant, .avant all, .dans the zone of frequency ranging between 200 and 500 Hz. Of a manner similar to what occurs for the capillary serpentines 26 and 34, the curves of the capillary tube or also of the narrow conduits of connection between the capillary .du end and the inlet of the evaporator, i.e. in the area of the item 14, .provoquent vibrations. Since the accelerations are .directement proportional with square the rate of flow, and conversely proportional with the radius of curvature of control, the danger of vibration is particularly considerable in the area of the curves of the portion -: capillary, .dans which, because of the low .pression, and consequently, of a considerable volumetric proportion of the vapor, it occurs .des high rates of flow.

In the forms of execution of figures 4 to 7, the disturbing noises are avoided, in spite of the employment of, capillary portions 26, 34 which are rolled up in a clamped way, by the fact that in the vicinity immediate of .ces rollings up, one has attached of a rigid manner with the mechanical .point de vue, additional masses 1 whose size .est such as the amplitudes of vibrations of the system - become notably lesser. Instead of employing a special additional mass, one can particularly make heavy also the control of suction. Moreover, one can couple rigidly with the sites of the tubular conduits which take into consideration, of other structural components - of the refrigeration apparatus, which exist without that, preferably .des structural components which, because of their size and their form, have little tendency to sound radiation.

<Desc/Clms Page number 6>

Additional mass deadened: seuse of the noise must be substantially as considerable as the flow of the refrigerating agent into 3 to 15 minutes. Masses even more considerable are permissible, but in general do not get any additional reduction of the noise.

One obtains .des forms of execution particularly advantageous of the present invention, when one completely avoids rollings up or serpentines 26 or 34, which were used to discharge the end from capillary in figures 4 and 6. The forms .d' execution for this purpose are represented on figures 8 to 14. Onto figure 8, the capillary tube 36 is welded by soft welding into 37 with the tube of suction 35. On figure 9, one envisaged a pipe of tightening 40 which brings the capillary tube 39 in good thermal contact with the tube of suction 38. Following figure 10, for the fixing from capillary the 39 on the tube of suction, one used a metallic spiral of wire 2. The form of execution of figure 11 watch a capillary tube 43 which is introduced in right line .dans it, tube of suction 4,2, it, prolongation 41 of the .tube of suction being brazed to capillary to the site of introduction 44. , and being welded by soft welding at the low end .du tube 42. In order to discharge the site from introduction, the straight portions 43 and 41, are welded by soft welding into 4,5.

Figure 12 watch a form of execution particularly advantageous. Here tubes 43 and 41 are mechanically joined together one with other by .un collar 46, in front of the site .d' introduction brazed 44. Has places it collar one can also use a rolling up - of metallic wire, or, following figure 13, a tube of tightening 47. For the corrosion protection, all the site of connection, like it, is shown in figure 14, can be covered, of a coating 48 out of plastic or plastic, this layer of plastic or plastic also preventing, moreover, the rattling of the tubes. Also in the form .d' execution of figure 8, the beginning of the connection by welding between the tubes, can be discharged by means of a collar or from a metallic rolling up of wire.

One .doit to treat of a corresponding manner the connection between the capillary 13 and the control of suction 16, in the area of item .25, i.e. in the vicinity of the evaporator. One must avoid laugh curves with low ray in the capillary one, front all, .dans the area ranging between the items 25 and 14 of figures 1, 2 and 3, because there are the highest speeds here. Also the capillary serpentine which is in generated upstream area of heat transfer, can be attached with the control of suction by means of a collar. For this purpose, one represented on figures 15 to 17 a form of execution chosen as example. Figure 15 watch a cut, figure a 16 sight into planar and figure 17 a lateral rise .de this site in - connection. 62 indicates the enroule= lies .du capillary front the site of introduction 63 .dans the tube of suction 64. A fixed collar 65 the middle area of the serpentine or rolling up on the tube of suction 64. 66 and 67 indicate rollings up of, metallic wire or collars which fix it - capillary tube 71 coming of the desiccator, and the capillary tube 72, leading to the exchanger of heat, with the tube of suction 68 which leads to the compressor.

By means of grips 69 - and 70, rollings up or the serpentines are maintained in .des sites together which face. The whole of the tubular system can, together with the evaporator, covered being of plastic or .plastic by a process of sintering to fluidization: - Lor_que section 25-14 of - capillary e3t relatively long (more than 1/10 and, preferably, 1/4 of the whole length of the .capillaire), II intervenes in the remainder of: capillary lesser speeds that during normal construction, and the danger of vibrations is reduced .d' a corresponding manner. Under these conditions, one can improve compared to normal constructions, the heat transfer between capillary the .et the control of suction, thanks to the provision represented schematically on figure 18. The control of suction 49, comes into 50, of the evaporator, and is led, into 51, with: compressor. The tube - capillary east connects 53 to the cartridge of desiccation 54, or tubular control coming of the conden- sor, and it is led, .par the most short way, without interposition .d' a rolling up, with the control of suction 49. Since in first section 55 - the capillary one there exists only of the liquid refrigerating agent, .cette portion of capillary can be rolled up with clamped whorls on control - of suction 49. In the .consécutif course of capillary, one uses rollings up with step substantially more lengthened, left that in .dépit the speed which rises, because of the formation of the vapor, at the time of the relaxation of the refrigerating agent, the peripheral component rate of flow and, consequently, the vibration of the tubular .conduite .demeurent sufficiently low. The .dernière portion of capillary (approximately 1/4 the total length), is not rolled up on the control of suction, but it is led to the wide state or with rollings up to step very lengthened 56 (approximately 150 mms diameter) in 57, with the evaporator. The portion of the capil- laire rolled up on the control of suction is Téu- denies as firmly as possible with control .d' suction, .afin d' to obtain a good thermal contact. This can be assured .par the fact that the capillary one and the control of suction is welded by

<Desc/Clms Page number 7>

soft welding (if necessary by immersion in a tin bath) over the entire length of] '.enroulement, or on considerable sections. The capillary one can be also brazed in several places, preferably into 58 and 59, with the control of suction. In other places, in particular in the area where rollings up have a considerable step, for example in 60 and 61, the capillary one can be also maintained by solder by means of fixed rollings up of metallic wire on the control of suction. Lastly, II is possible amusement to provide with a coating of plastic or plastic the system .de led 4,9 to 52, .par sintering with fluidization. This is carried out preferably, once the system of conduits is connected to] 'evaporator, so that the evaporator and tubes 49 and 52 are treated superficially on the only one way. Rolling up 56 is attached with the evaporator front or after the coating by sintering, in order to prevent that this rolling up runs up against the evaporator or the inner coating - refrigerator and determines in consequence of the .cliquetis.

All the characteristics, all the objects or all the examples which were exposed in description or were represented on the drawing, separately or in combination, must be regarded as making portion of the invention.